United States Patent [19]

Casasent

[11] Patent Number:

4,906,099

[45] Date of Patent:

Mar. 6, 1990

[54]	METHODS AND APPARATUS FOR OPTICAL PRODUCT INSPECTION		
[75]	Inventor:	David P. Casasent, Pittsburgh,	Pa.

[73] Assignee: Philip Morris Incorporated, New York, N.Y.

[21] Appl. No.: 115,428

[22] Filed: Oct. 30, 1987

[56] References Cited

U.S. PATENT DOCUMENTS

988,720	4/1911	Kohler 350/420
3,069,654	12/1962	Hough 340/146.3
4,242,702	12/1980	Kuni et al 358/106
4,493,554	1/1985	Pryor et al 356/394
4,515,480	5/1985	Miller et al 356/394
4,618,989	10/1986	Tsukune et al 382/25

FOREIGN PATENT DOCUMENTS

205628 12/1986 European Pati Off. . 2704983 8/1978 Fed. Rep. of Germany 356/394 61-290583 12/1986 Japan .

OTHER PUBLICATIONS

Van Daele et al., "The Leuven Automatic Visual Inspection Machine", Proceedings of the Society of Photo-Optical Instrumentation Engineers, vol. 182 (1979) pp. 58-64.

Van Daele et al., "Automatic Visual Inspection of Reed Switches", Optical Engineering, vol. 19, No. 2, (Mar.-/Apr. 1980) pp. 240-244. Wai-Hon Lee, "Computer-Generated Holograms; Techniques and Applications", in *Progress in Optics*, vol. XVI, pp. 121-232, North-Holland Publishing Company, Amsterdam, 1978.

D. Casasent, "Coherent Optical Pattern Recognition", Proceedings of the IEEE, vol. 67, No. 5, May 1979, pp. 813-825.

G. R. Gindi et al., "Optical Feature Extraction Via the Radon Transform", Optical Engineering, vol. 23, No. 5, Sep./Oct. 1984, pp. 499-506.

D. Casasent, "Computer Generated Holograms in Pattern Recongition: A Review", Optical Engineering, vol. 24, No. 5, Sep./Oct. 1985, pp. 724-730.

W. H. Steier et al., "Optical Hough Transform", Applied Optics, vol. 25, No. 16, Aug. 1986, pp. 2734–2738. C. Barney, "Hologram Filter Spots Images from Any Angle", Electronics, Sep. 4, 1986, pp. 37–38.

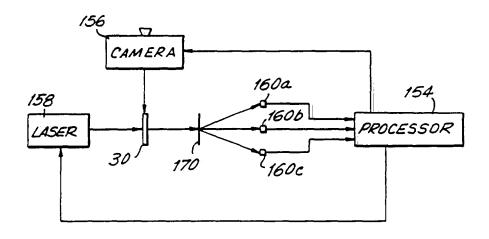
R. Krishnapuram, "Hough Space Transformations for Discrimination and Distortion Estimation", Computer Vision, Graphics, and Image Processing, vol. 38, No. 3, Jun. 1987, pp. 299–316.

Primary Examiner—Richard A. Rosenberger Attorney, Agent, or Firm—Robert R. Jackson

[57] ABSTRACT

Products having optically detectable straight line segments are inspected for acceptability by forming one or more one-dimensional images of the product in which properly aligned straight line segments are respectively focused to points in the image. Such parameters as the location and image intensity of these one-dimensional image points are used to determine whether or not the product is acceptable. An optical Hough transform underlies these product inspection techniques.

34 Claims, 18 Drawing Sheets



2026230391